TraSH-SN: A Transport Layer Seamless Handoff scheme for Space Networks

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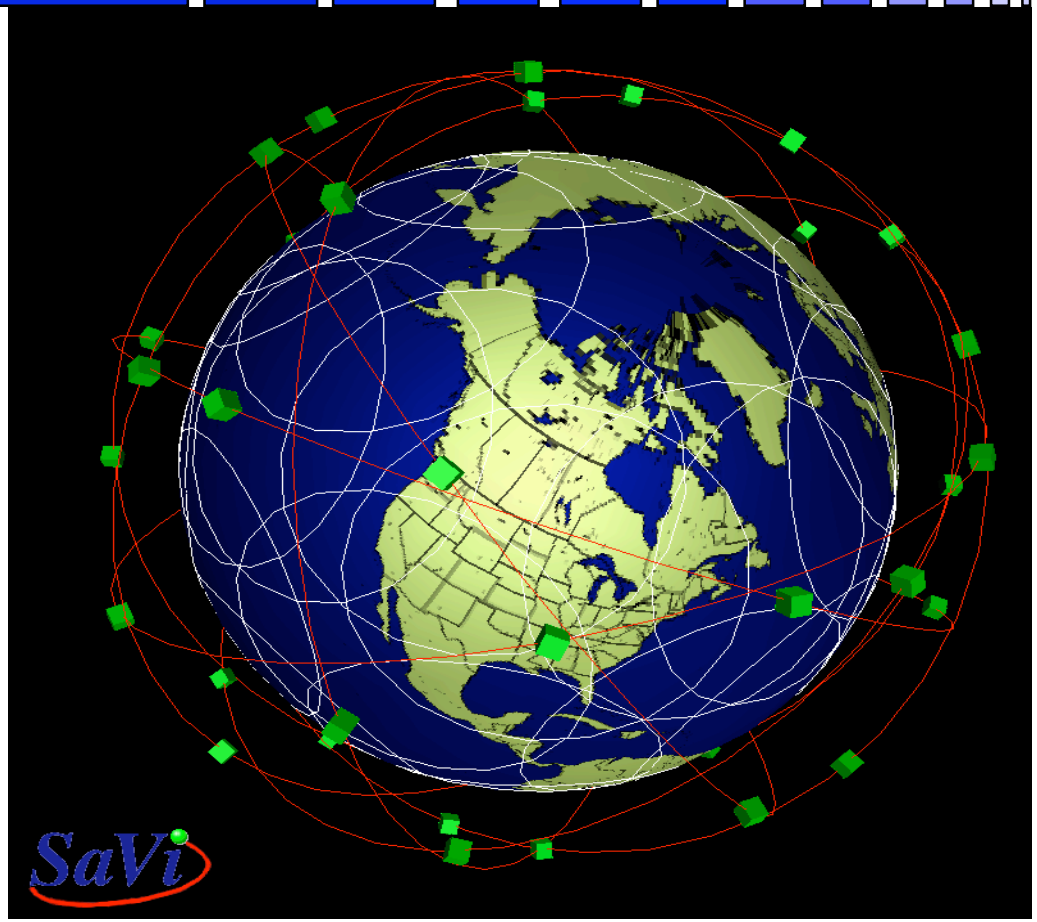
Outline of this talk

- Handoffs in satellite IP networks.
- Introduction of SCTP and multi-homing.
- Handoff procedures of TraSH-SN.
- Location management and data transfer path in TraSH-SN.
- Vertical Handoff using TraSH-SN.
- Issues open to research.

Handoffs in LEO Satellite Constellations

Handoffs in satellite IP networks

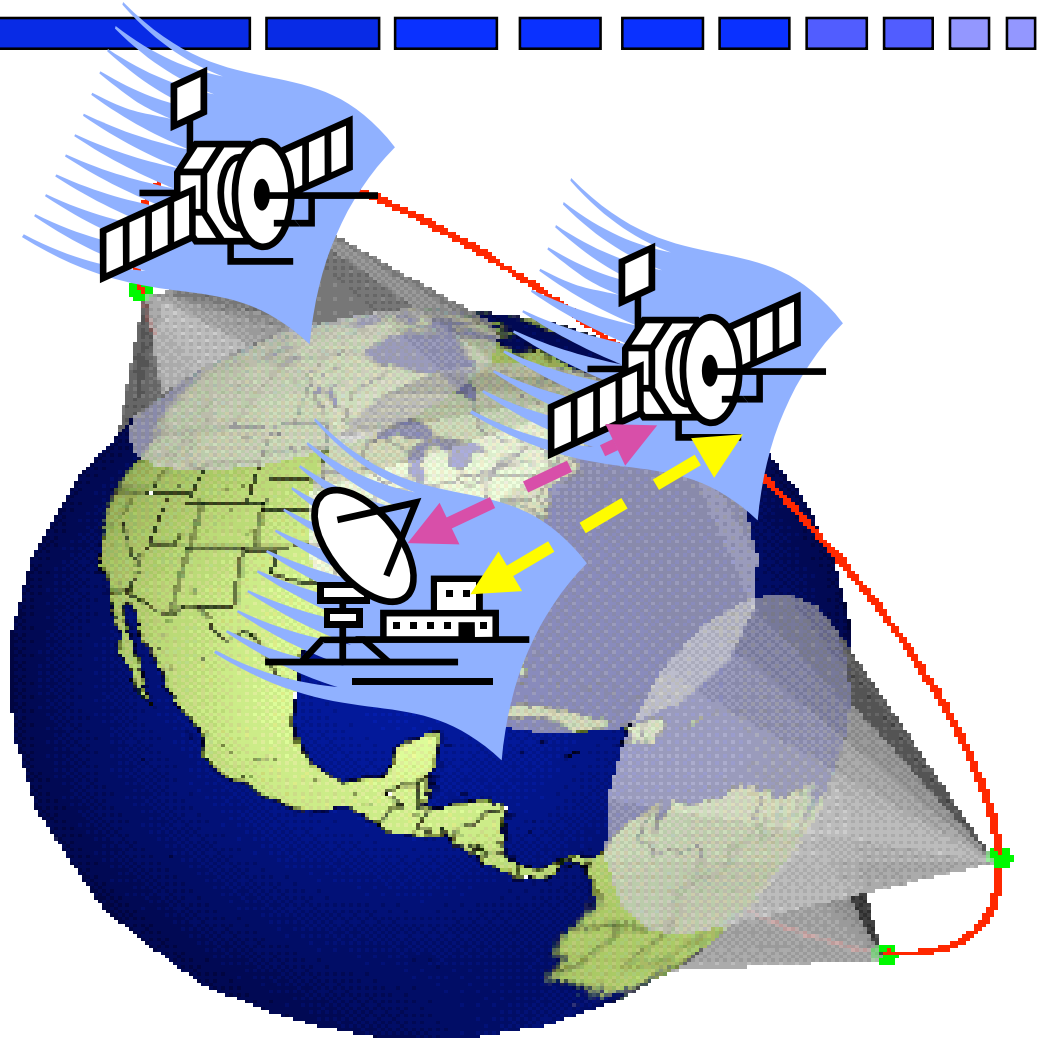
- Link Layer Handoff
  - Inter-satellite handoff
  - link handoff
  - Spotbeam handoff
- Network Layer Handoff
  - Satellite as a router
  - Satellite as a mobile host



A Globalstar design, with 48 active satellites in 8 planes of 6.

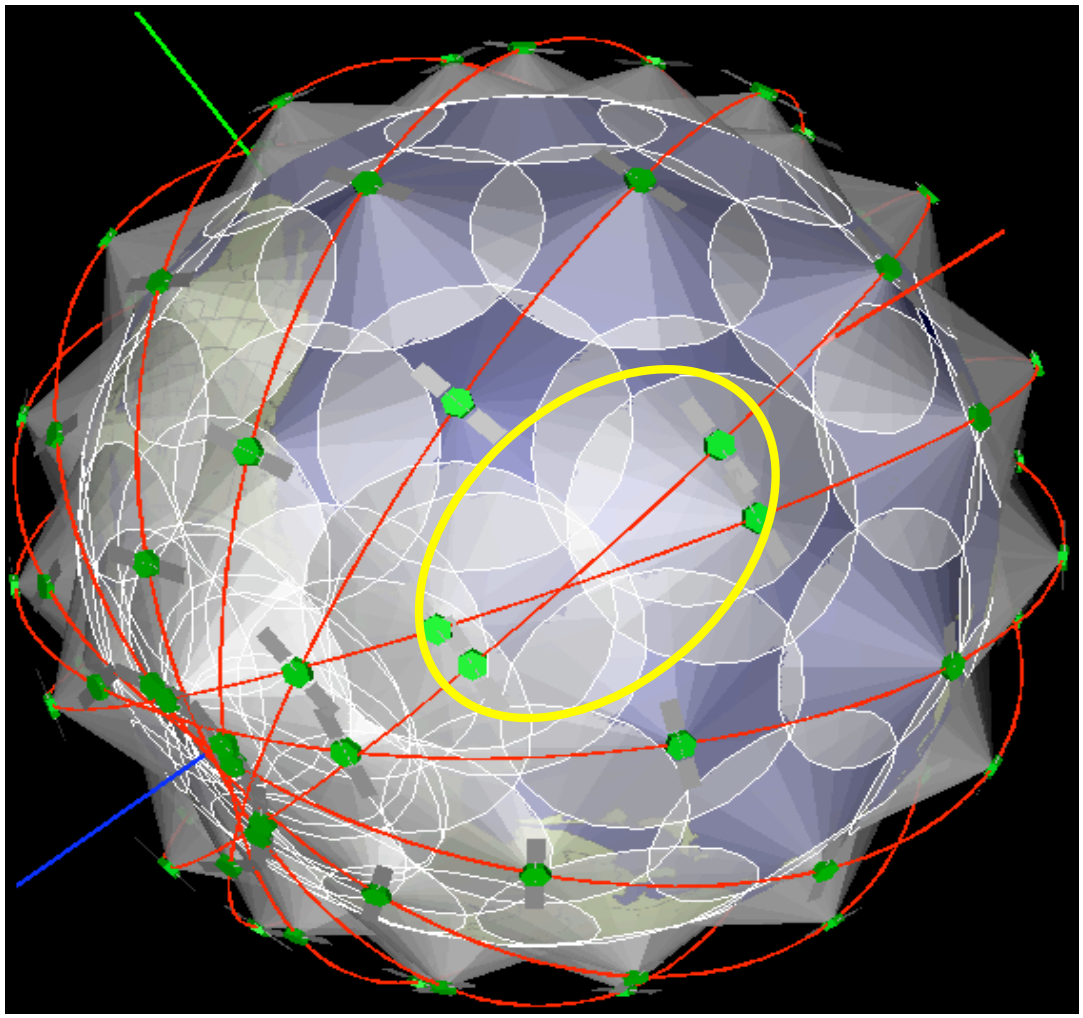
Inter-satellite Handoff

- The movement of satellite causes a Ground Station being handoffed from one satellite to another.
- Similar to inter-switch handoff in the case of terrestrial mobile network.



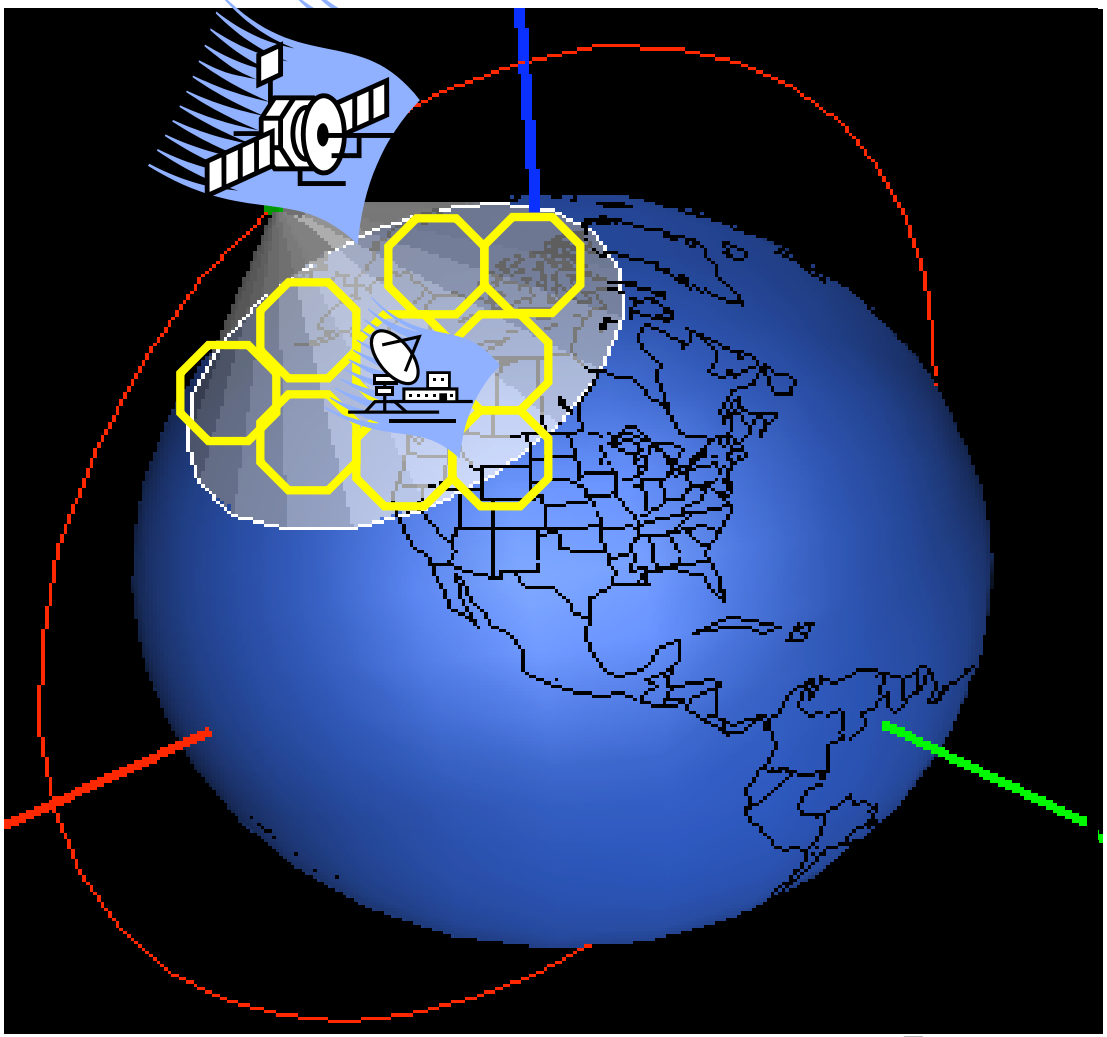
Link Handoff

- An Iridium design, with 96 active satellites in 8 planes of 12.
- Dynamic connectivity structure caused by satellite movement requires rerouting the on-going application to new Inter-satellite Links (ISL).



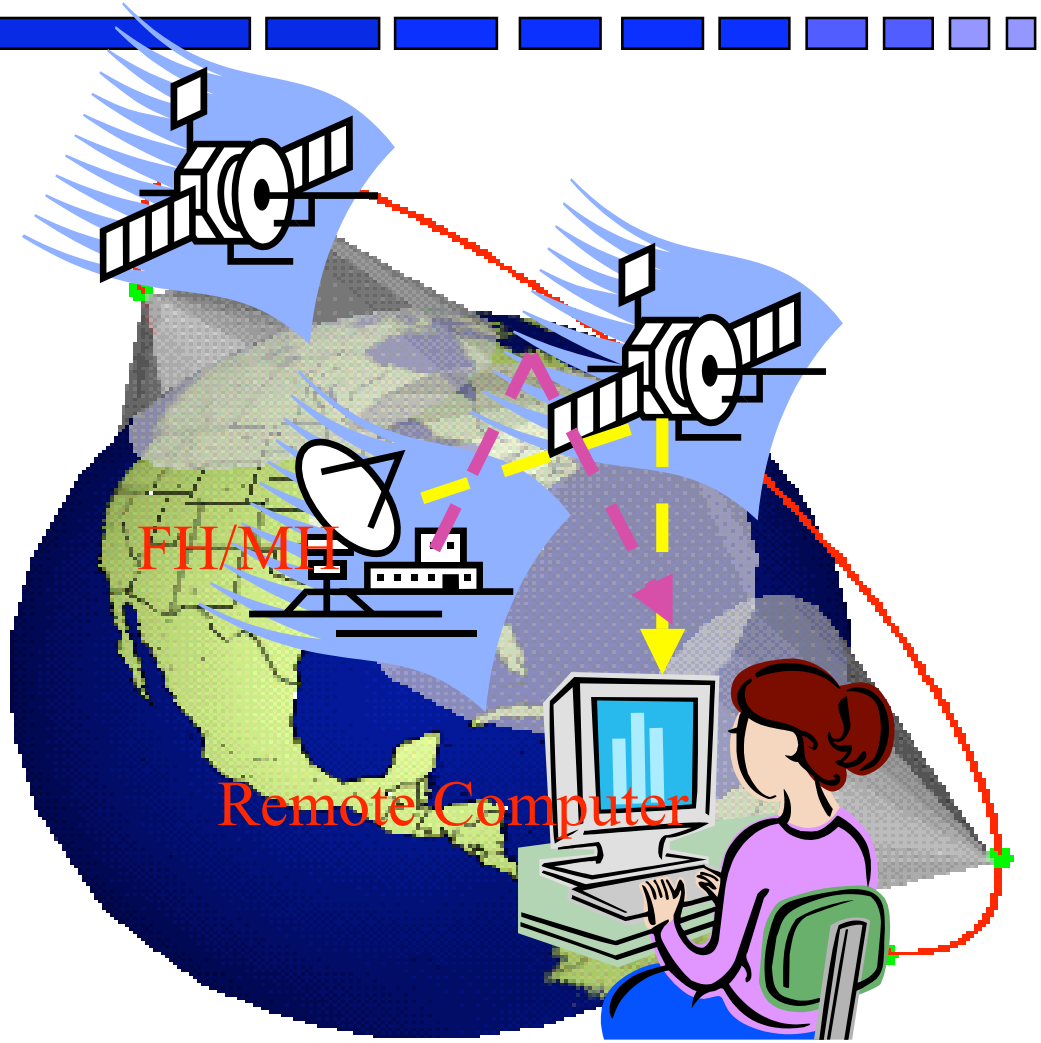
Spotbeam Handoff

- Spotbeam handover occurs when the existing application is transferred to neighboring spotbeam.
- Similar to intra-switch handoff in the case of terrestrial mobile network.



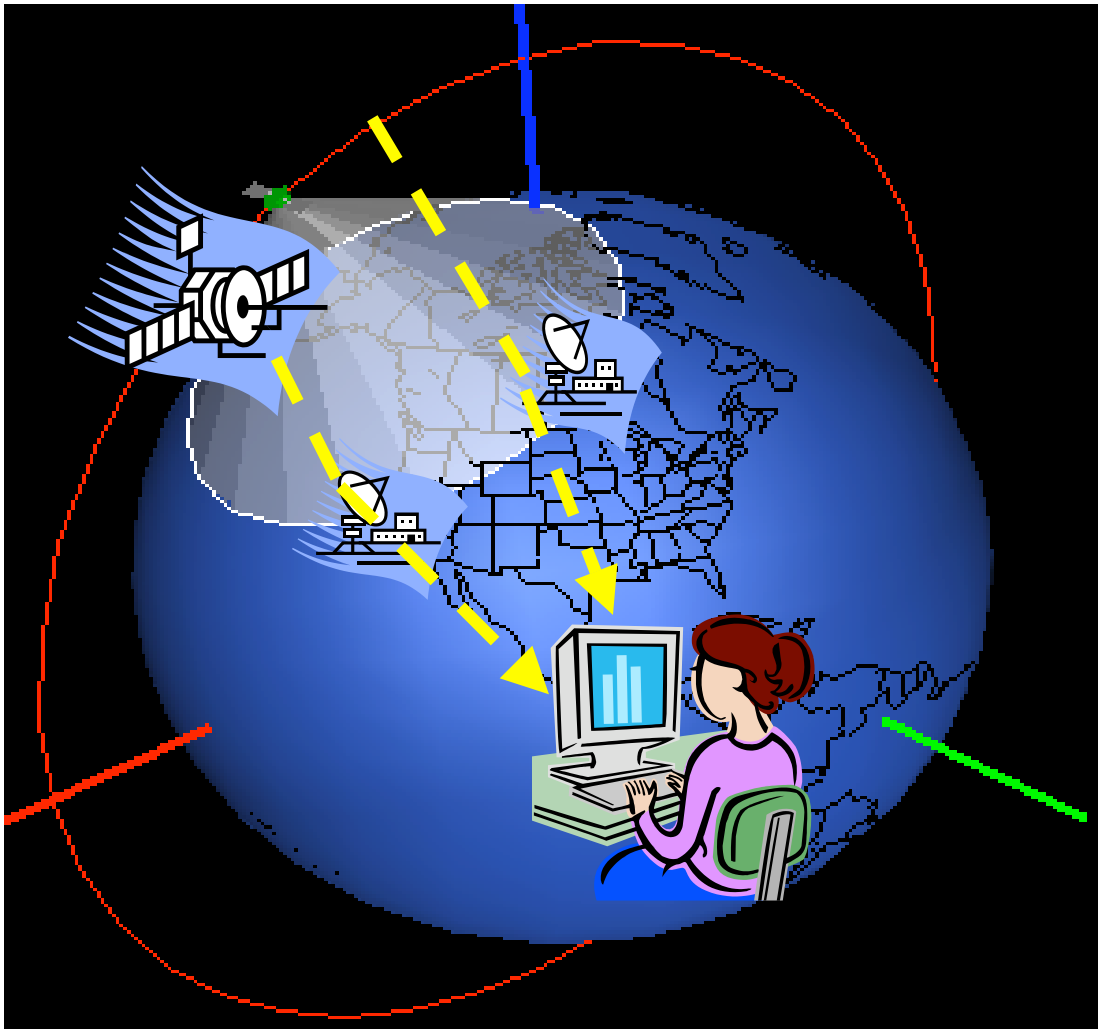
Network Layer Handoff
Case 1: satellite as a router

- Satellites not equipped with devices generating or consuming data, but with IP routing devices.
- Satellites are allocated with different IP prefix.
- FH/MH need to maintain continuous connection with Remote Computer.



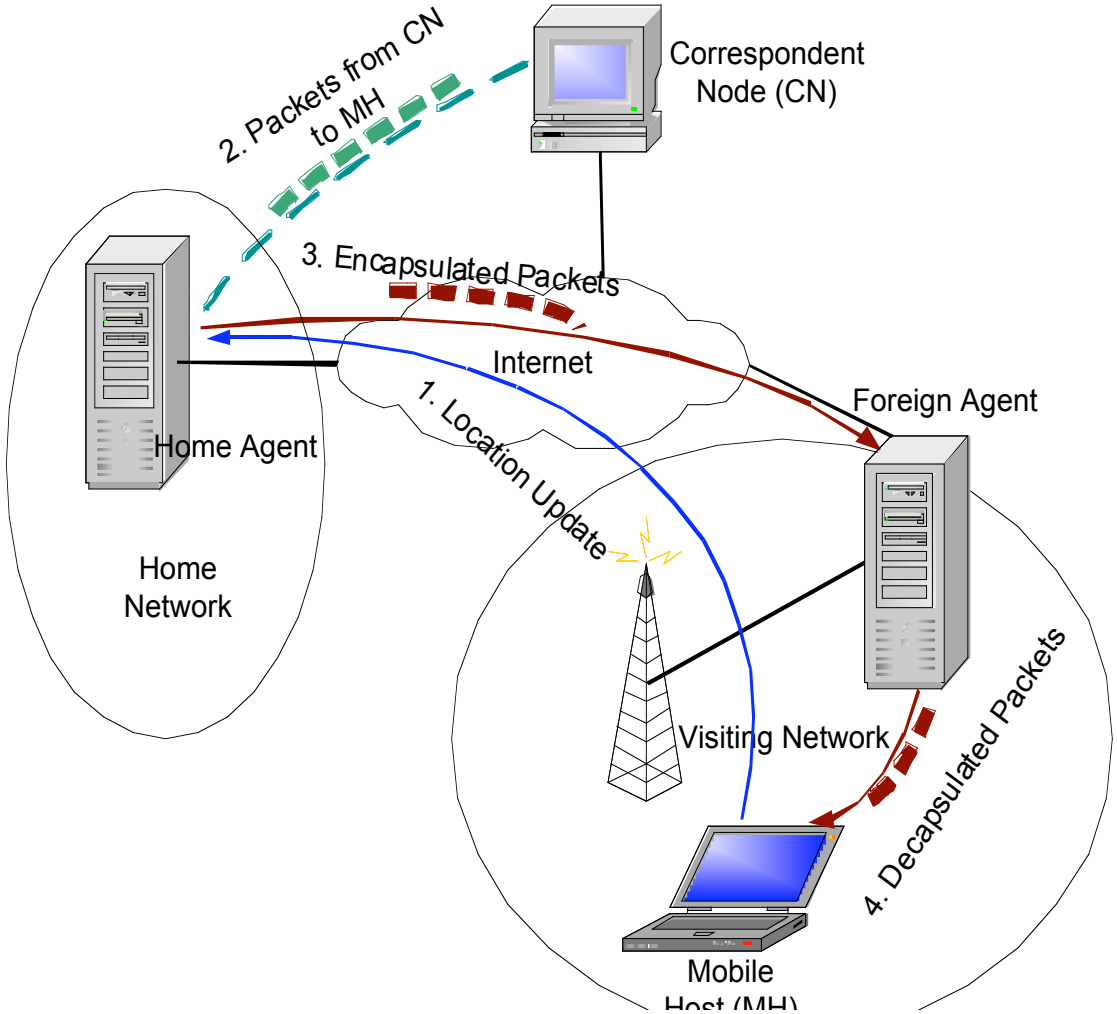
Network Layer Handoff
Case 2: satellite as a mobile host

- Satellite onboard equipments act as the endpoint of the communication.
- Ground stations are allocated with different IP prefix.
- Satellite need to maintain continuous connection with remote computer.



Mobile IP: Enabling IP host mobility without breaking higher level connection

- When Mobile Host moves to a new domain, a location update is sent to Home Agent.
- Packets from CN to Mobile Host are encapsulated and forwarded to MH's current care-of address.
- Packets are decapsulated and delivered to upper layer protocol.



Main Drawbacks of base Mobile IP

- Need modification to Internet infrastructure.
- High handoff latency and packet loss rate.
- Inefficient routing path.
- Conflict with network security solutions such as Ingress Filtering and Firewalls.
- Home Agent must reside in MH's home network, making it hard to duplicate HA to various locations to increase survivability and manageability.

Motivation

- NASA projects considering IP in space and Mobile IP
  - Global Precipitations Measurement (GPM)
  - Operating Missions as Nodes on the Internet (OMNI)
  - Communication and Navigation Demonstration on Shuttle (CANDOS)
  - NASA currently working with Cisco on developing a Mobile router
- Mobile IP may play a major role in various space related NASA projects
  - Advanced Aeronautics Transportation Technology (AATT)
  - Weather Information Communication (WINCOMM)
  - Small Aircraft Transportation Systems (SATS)
- Develop an efficient, secure and seamless handoff scheme which would be applicable to both the satellite and wireless/cellular environment.

Objective of TraSH-SN

- No need for install new hardware or software component in Internet infrastructure.
- Low handoff latency and packet loss rate.
- Efficient data path
  - Avoid triangular routing.
- Cooperate with existing network security mechanisms.
- Increased survivability, scalability and manageability.
- Suitable for satellite IP handoffs.

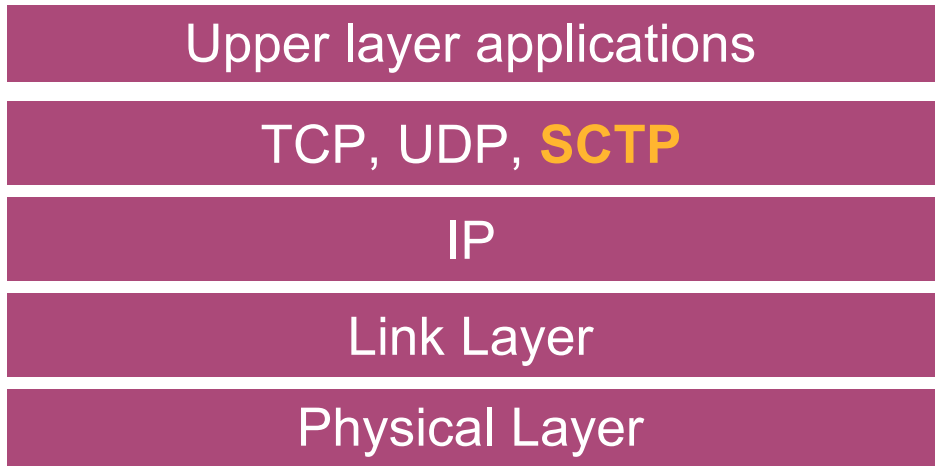
SCTP: A new Transport Protocol for Internet

What is SCTP?

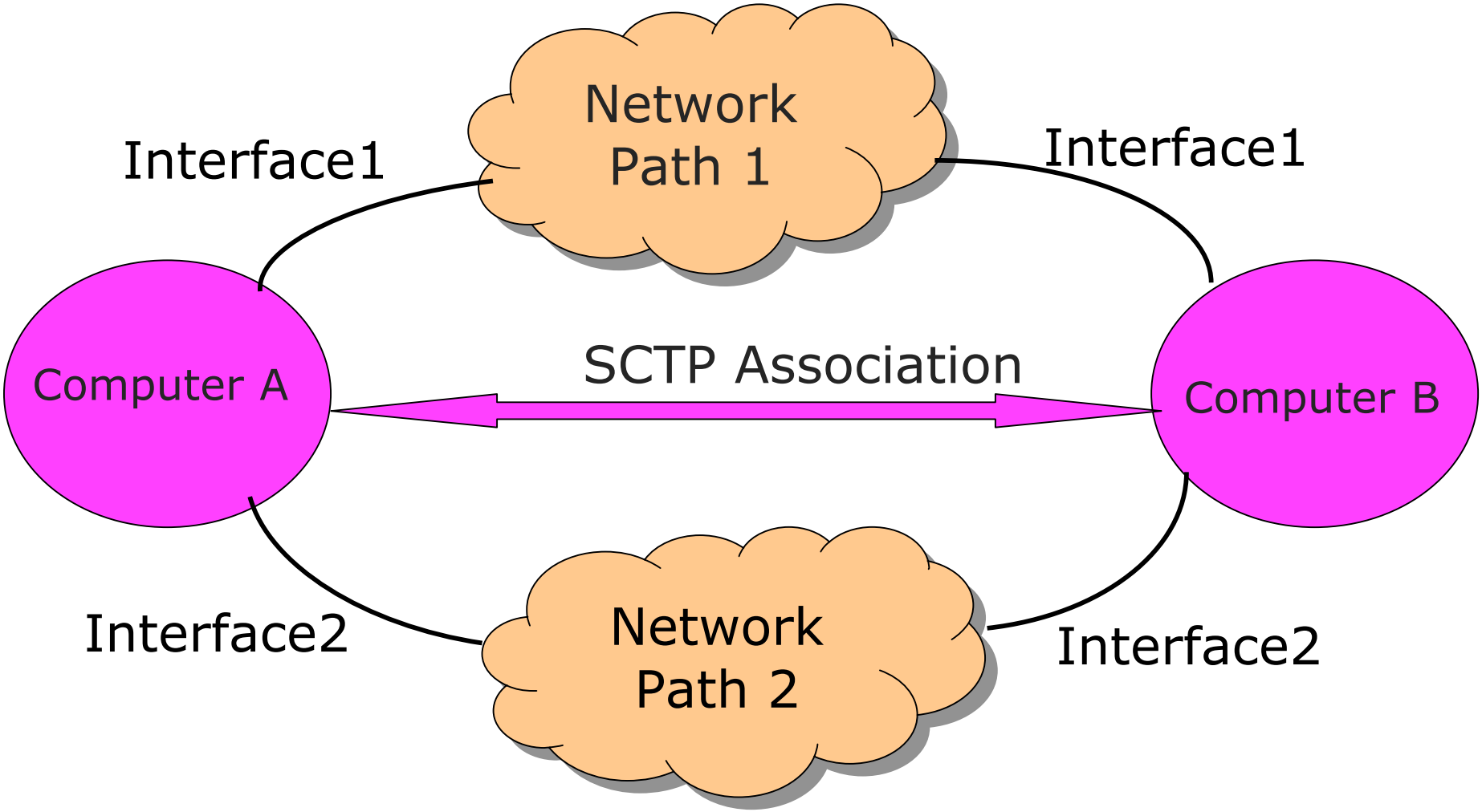
- SCTP: “Stream Control Transmission Protocol”
- Originally designed to support SS7 signaling messages over IP networks. Currently supports most of the features of TCP
- Standardized by IETF RFC 2960
- Reliable transport protocol on top of IP

TCP and SCTP compared

- Both of them are reliable transport protocols;
- Similar Congestion Control algorithms (slow start, congestion avoidance);
- SCTP has two new features:
  - Multihoming
  - Multistreaming

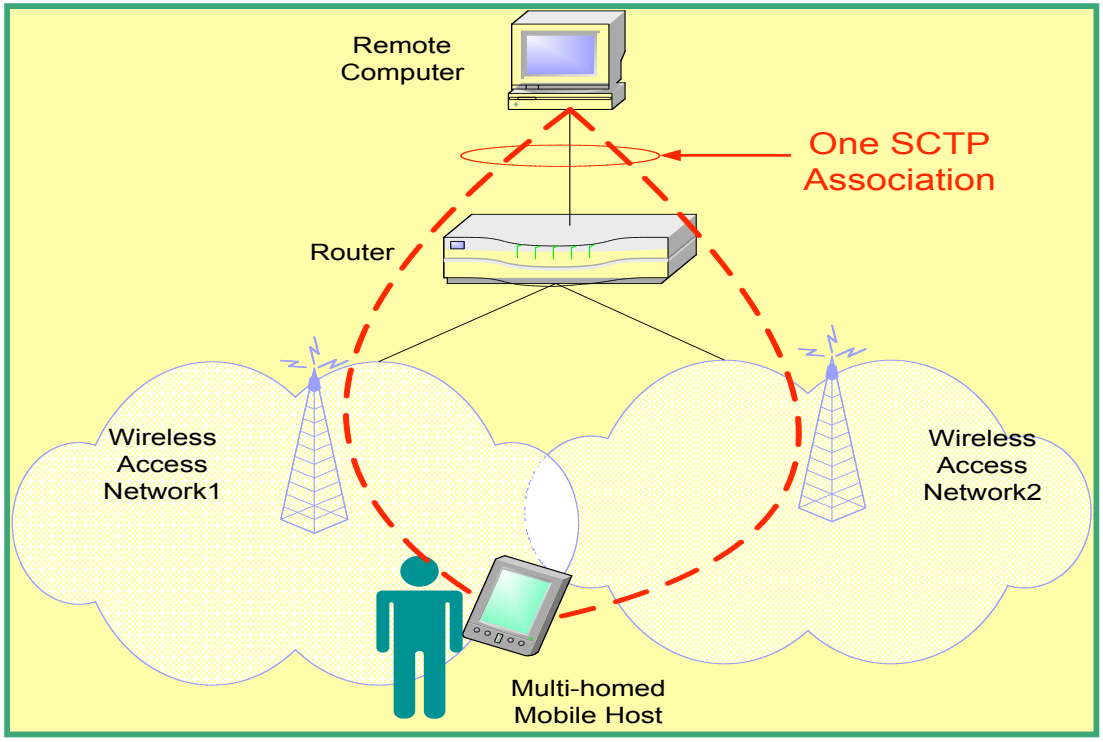


SCTP Multi-homing: Supporting Multiple IP Addresses in an Association.



Basic concept of TraSH-SN: Seamless Mobile Handover based on multihoming

- Mobile IP assumes the upper layer protocol use only one IP address to identify an logical connection. Some buffering or re-routing should be done at the router for seamless handover.
- SCTP support multiple IP addresses at transport layer naturally via multi-homing feature. When mobile host moving between cells, it can setup a new path to communicate with the remote computer while still maintaining the old path.



Advantages of TraSH-SN:

- Reduced packet loss and handover latency
- Increased throughput
- No special requirement on Router and Access networks.

Signaling Procedure in TraSH-SN

1.Satellite obtain a new IP address in new domain.

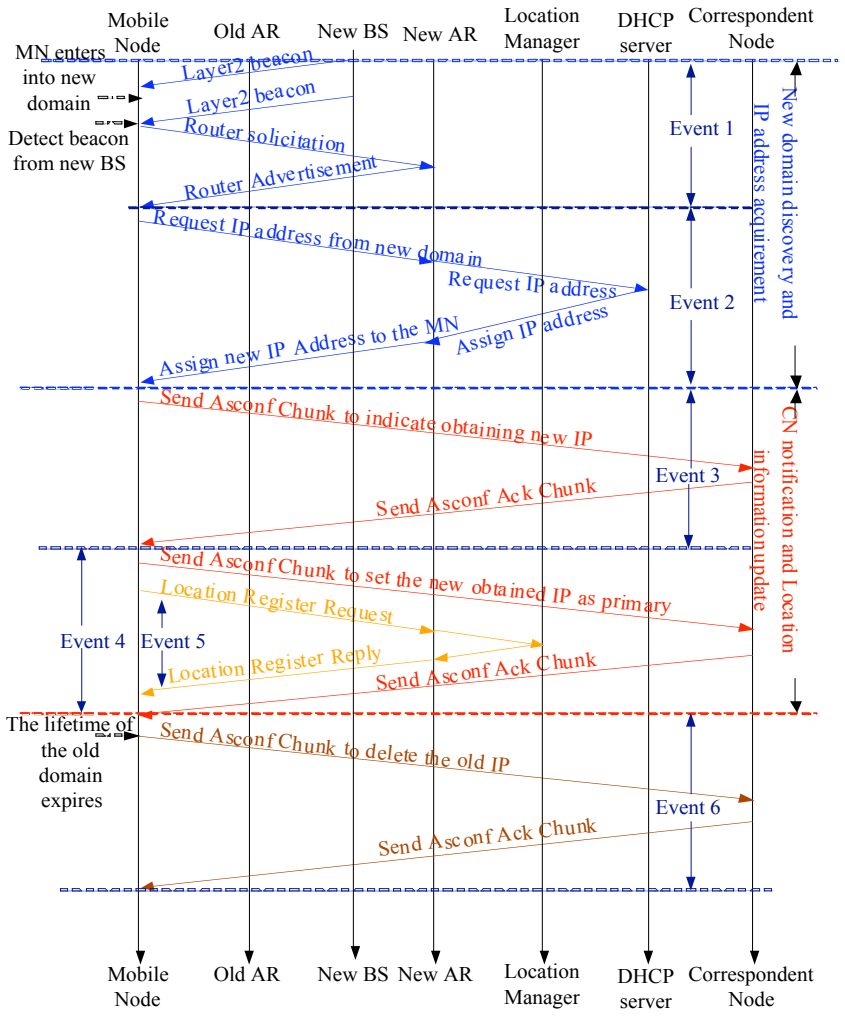
2. Satellite notify remote computer about the new IP address.

3. Satellite let remote computer set primary address to new IP address.

4.Update Location Manager.

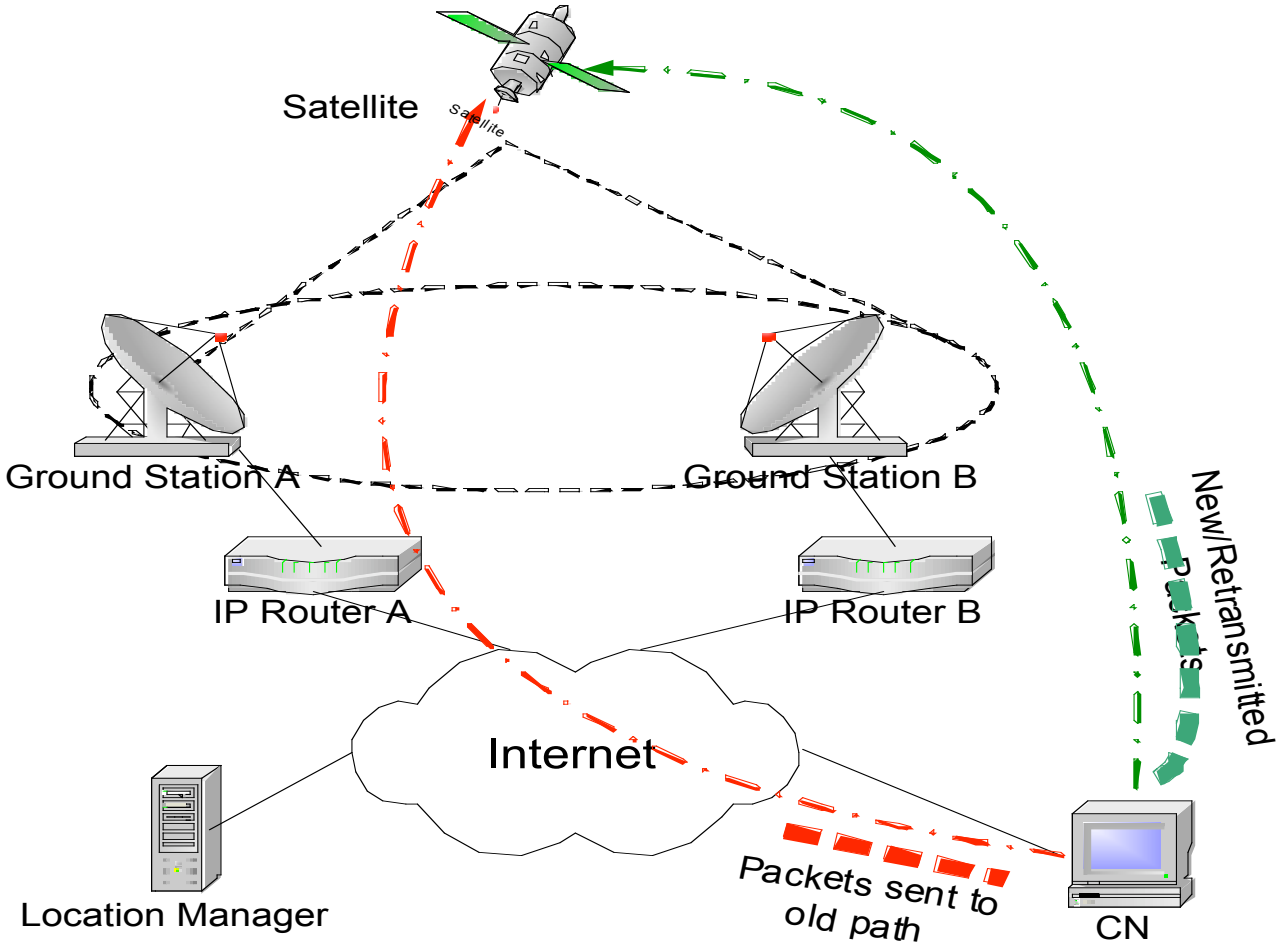
5. Delete or deactivate old IP address.

Timing Diagram of TraSH-SN



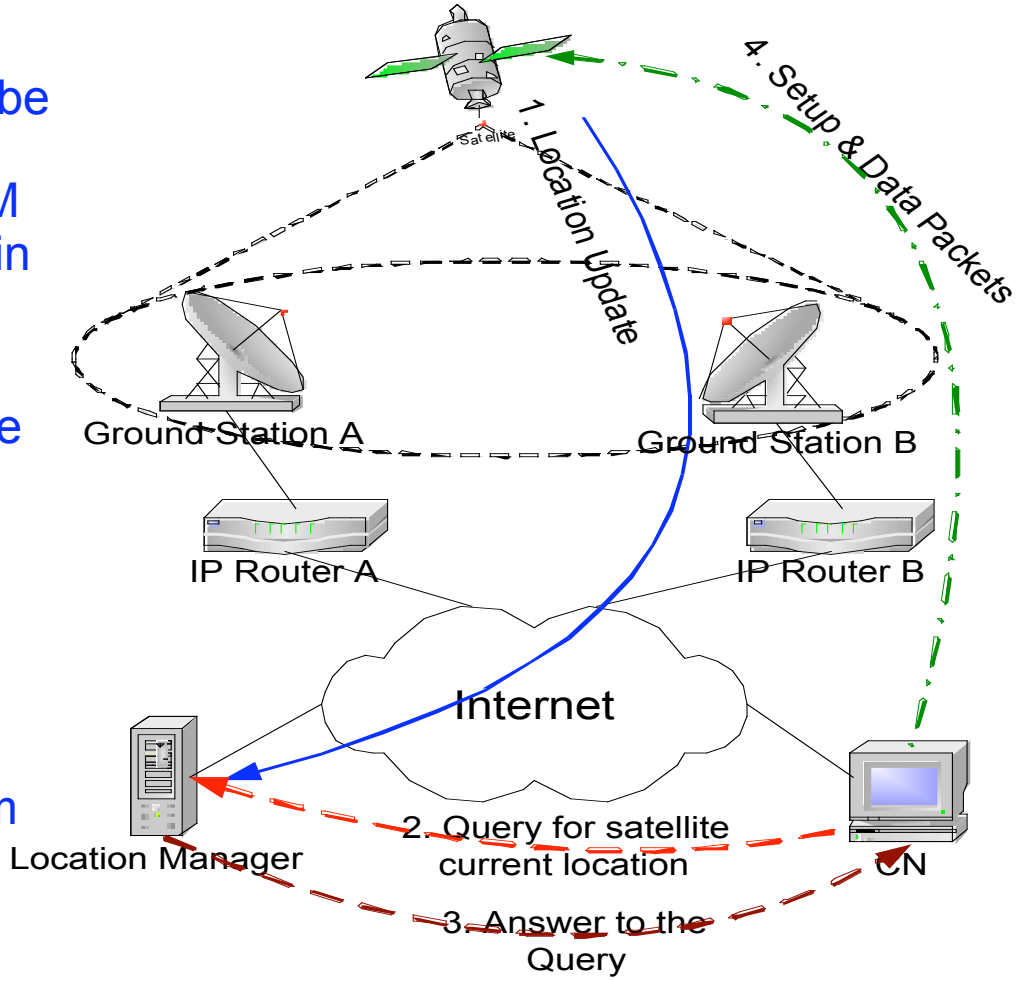
Timeline for SCTP based handover in concept

Data Transfer Path in TraSH-SN



Survivability of TraSH-SN Location Management

- Only location update/query needs to be directed to Location Manager (LM). Thus LM need not to be located in a specific network to intercept data packets.
- It is easy to replicate the Location Manager at distributed secure locations to improve survivability.
- LM can further be integrated with DNS server to reduce system complexity.



More Benefits of Centralized Location Management

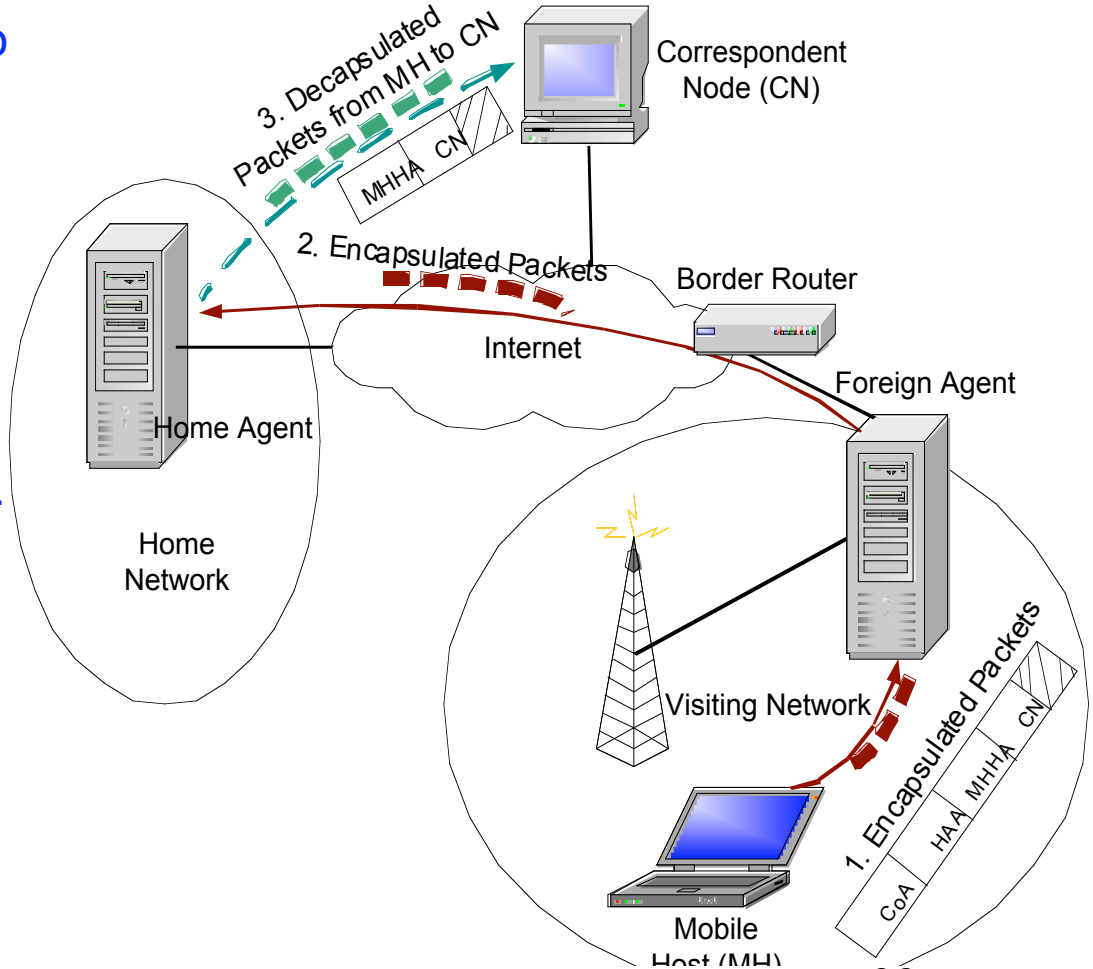
- Security: Storing user location information into a central secure databases is much more secure than scattering it in various Home Agents located at different sub-networks (in the case of Mobile IP).
- Scalability: Location servers do not intervene into data forwarding task, which adapts to the growth in the number of mobile users gracefully.
- Manageability: Centralized location management provides a way for an organization/service provider to control user accesses from a single server.

Objective of Mobile Security

- A mobile node (ground or satellite-based) should enjoy the same level of privacy as a node attached to a stationary network.
- Mobility algorithm should cooperate with existing Internet security mechanisms, e.g. Ingress Filtering, Firewalls, IPSEC, AAA (RADIUS/Diameter), etc.
- No excessive processing overhead incurred in terms of signaling delay, CPU time or memory space.
- Scalable to support large number of mobile users.

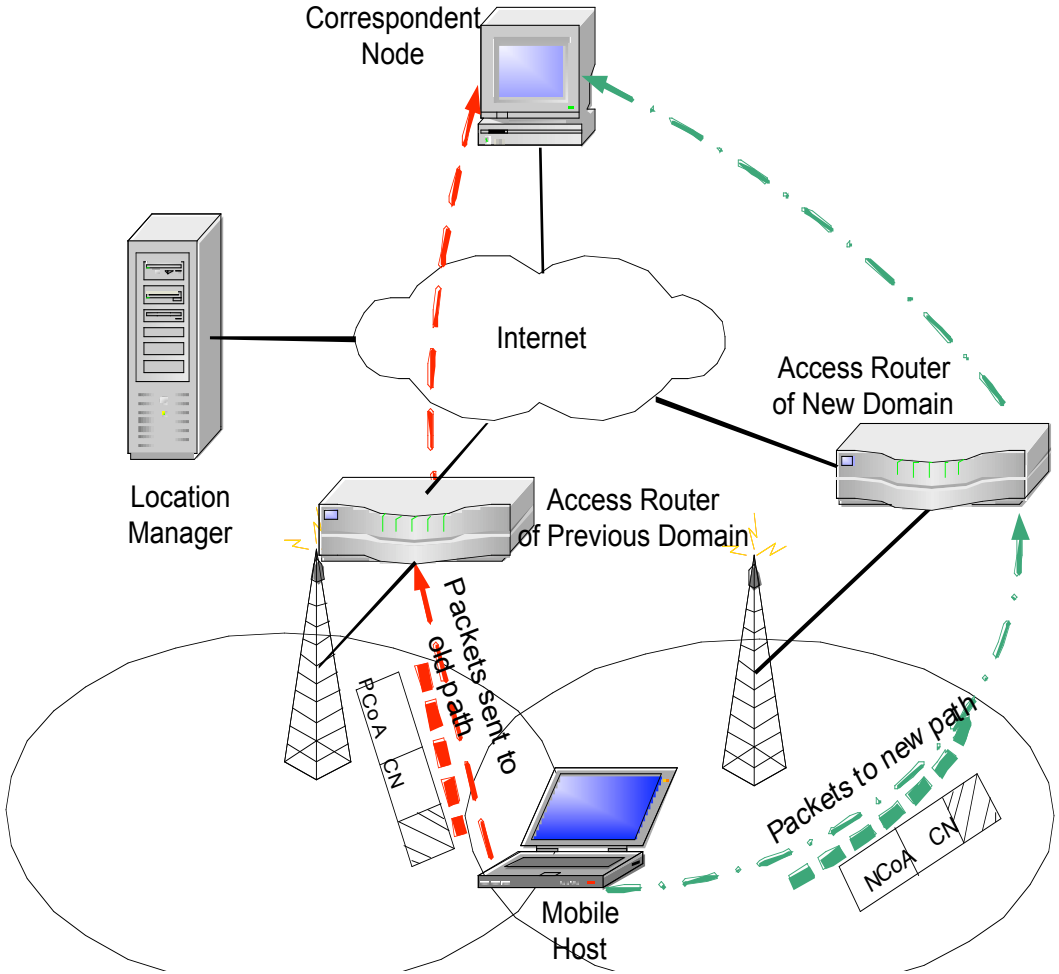
Interoperate Mobile IP with Ingress Filtering

- Ingress filtering is heavily used in current Internet to prevent IP spoofing and DoS attack.
- Ingress filtering border routers enforce topologically correct source IP address.
- Topological correctness requires MH using COA as the source IP address.
- Applications built over TCP/UDP requires MH always using its home address as source address.
- **Solution: reverse tunneling**



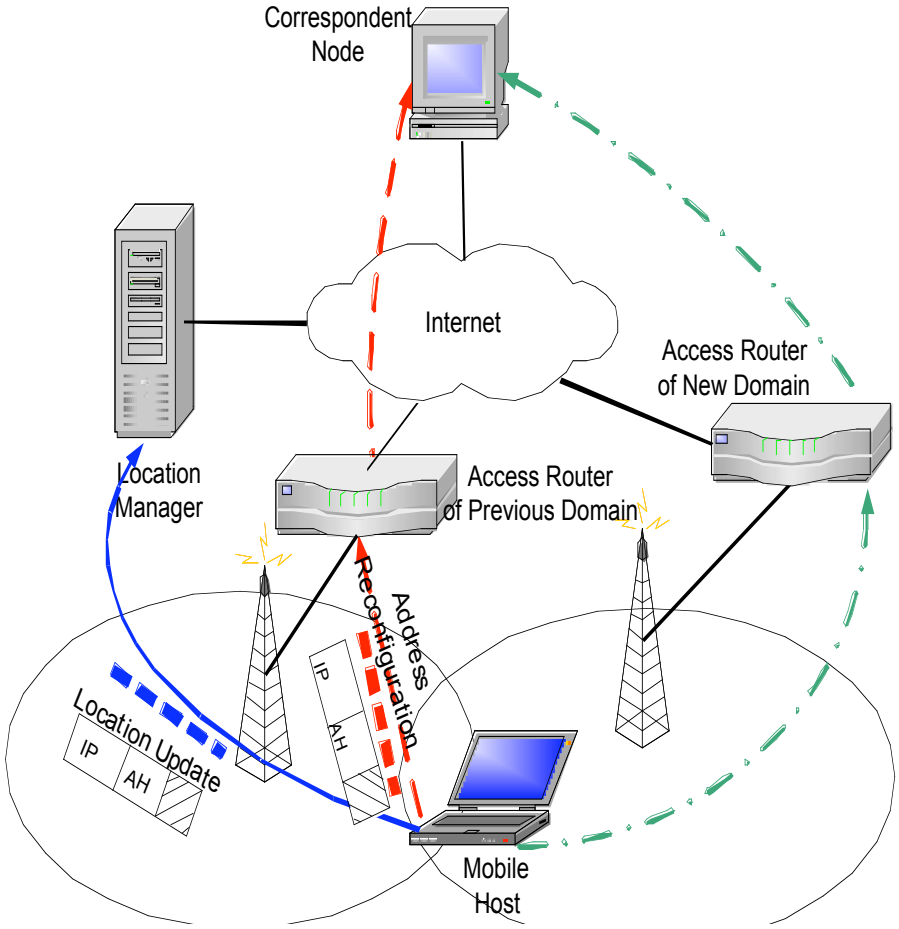
Interoperate TraSH with Ingress Filtering

- In TraSH, MH uses new CoA address directly to communicate with CN, it is already topologically correct.
- TraSH can incorporate well with ingress filtering, no need for tunneling.



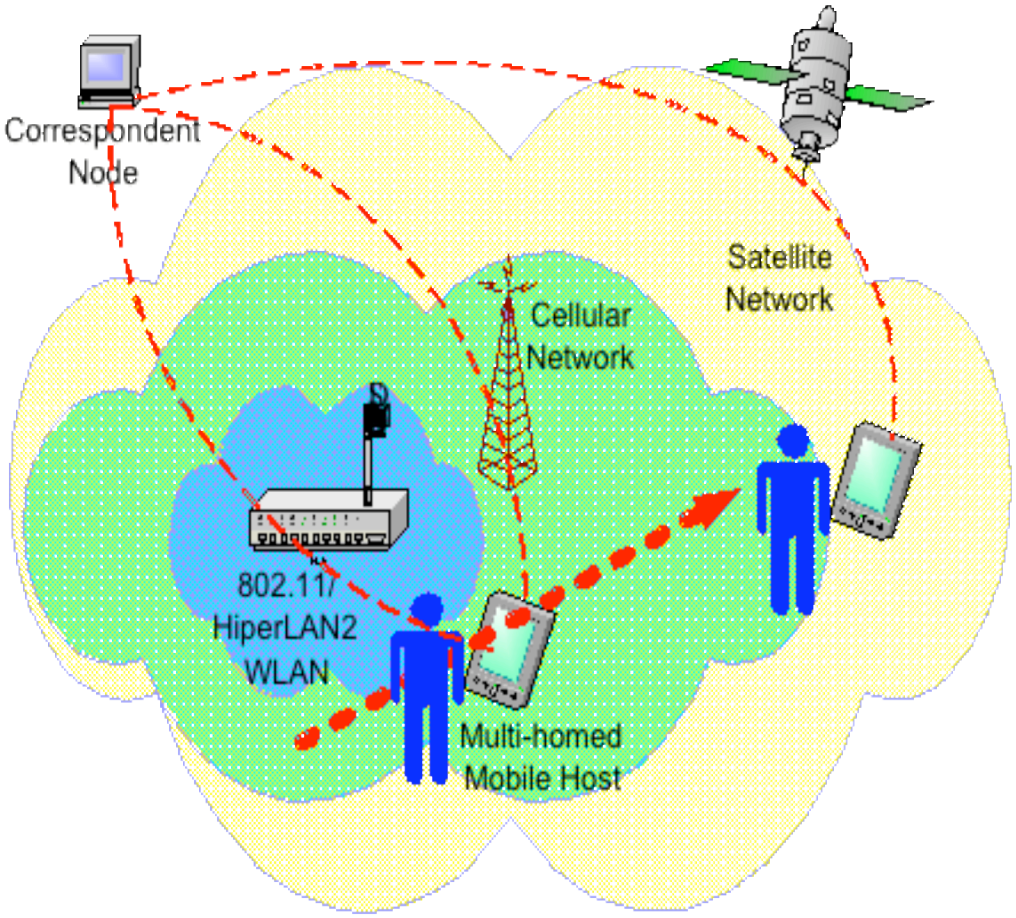
Increase the security of TraSH by IPSEC

- TraSH depends on dynamic address reconfiguration, which makes the association more vulnerable to be hi-jacked.
- An attacker can also send an bogus update to location manager, resulting all further association setup messages sent to illegal IP addresses---generally called redirection attack.
- All location update and address reconfiguration messages sent to LM and CN should be protected by IPSEC AH header.



Applying TraSH to Vertical Handoff

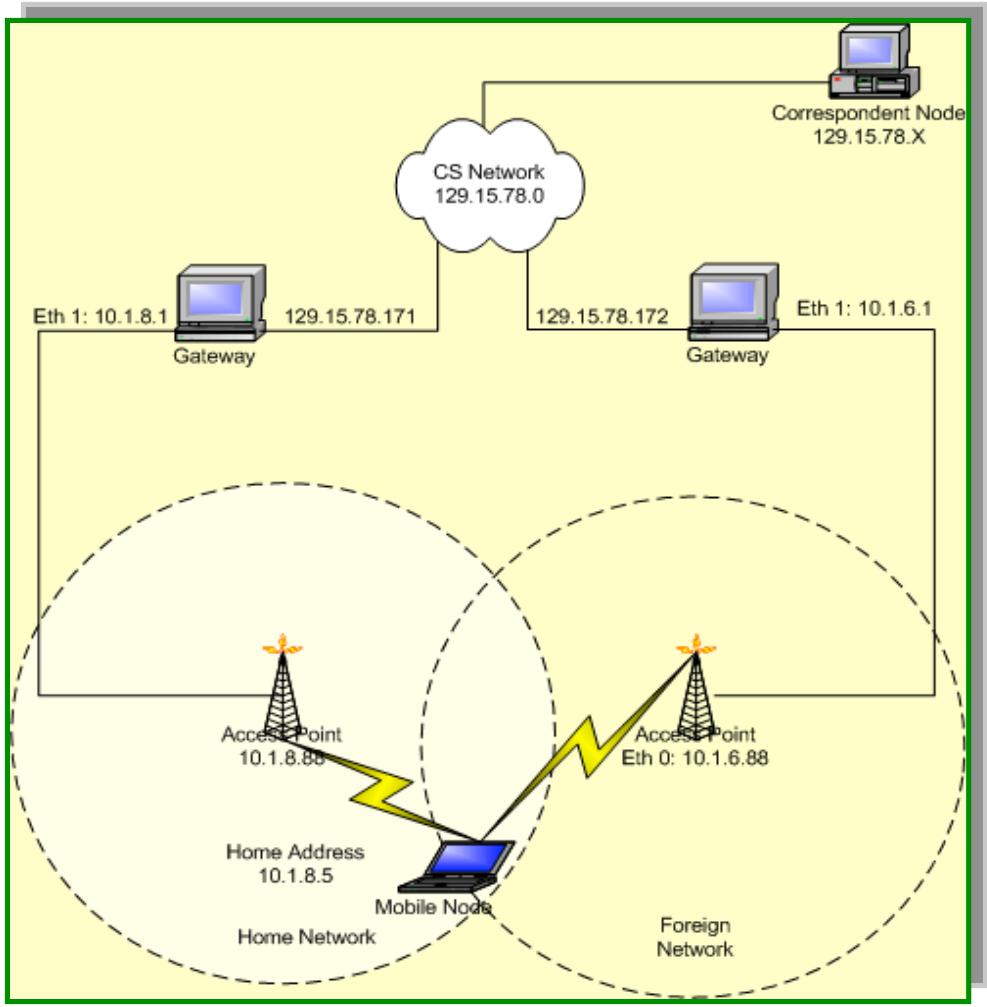
- Different access network technologies are integrating with each other to give mobile user a transparent view of Internet.
- Handover is no longer only limited to between two subnets in WLAN or between two cells in cellular network (horizontal handover).
- Mobile users are expecting seamless handover between different access networks (vertical handover).
- The mobility based on SCTP multi-homing is a feasible approach to meet the requirement of vertical handover.



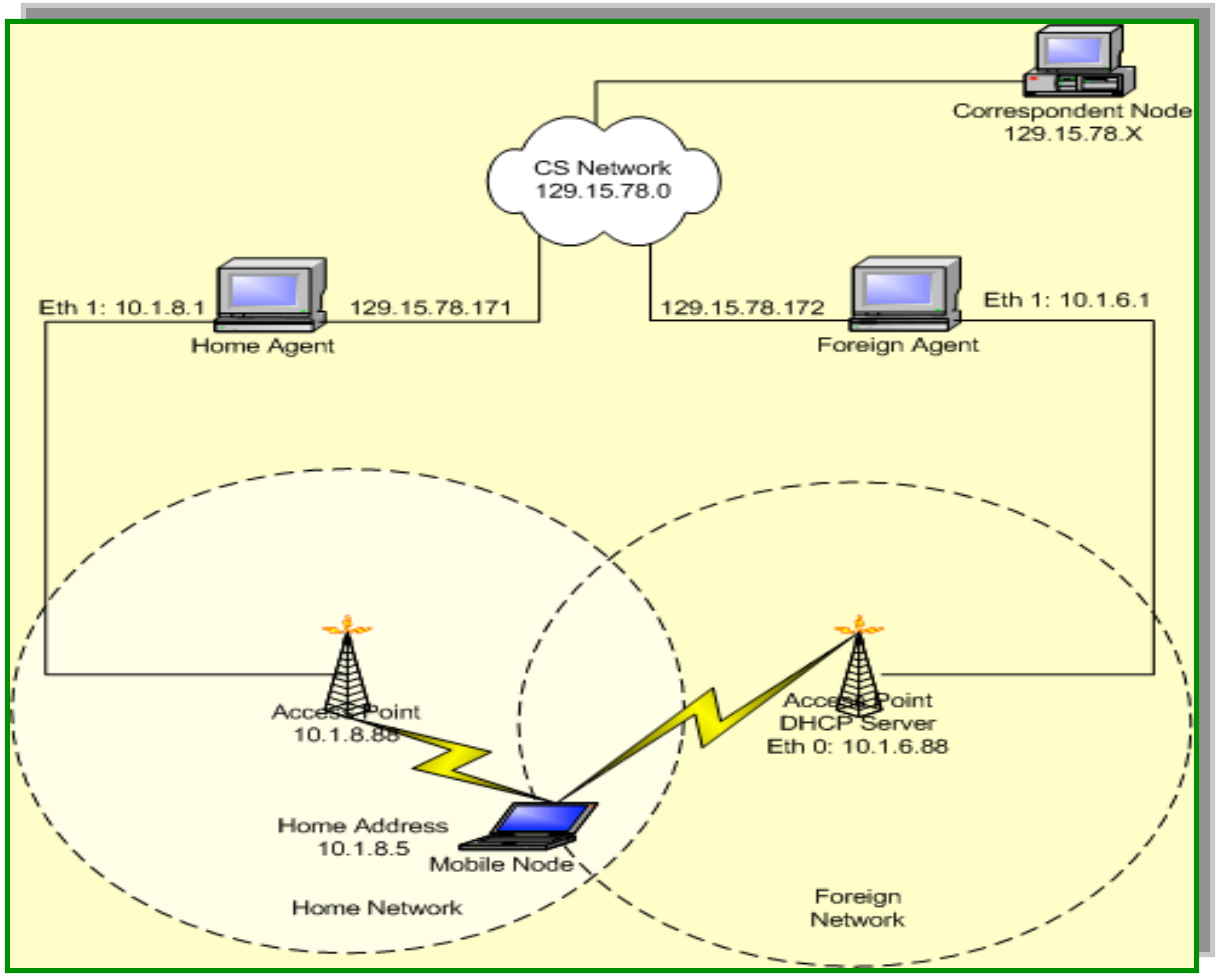
TraSH Testbed

Operation of TraSH Testbed:

- Link Layer is monitored to detect new AP signal strength.
- When a new AP is detected a new IP address is added to the association.
- When the new AP signal becomes stronger than the old AP signal, the Mobile Node notifies the Correspondent Node to make the new address the primary.



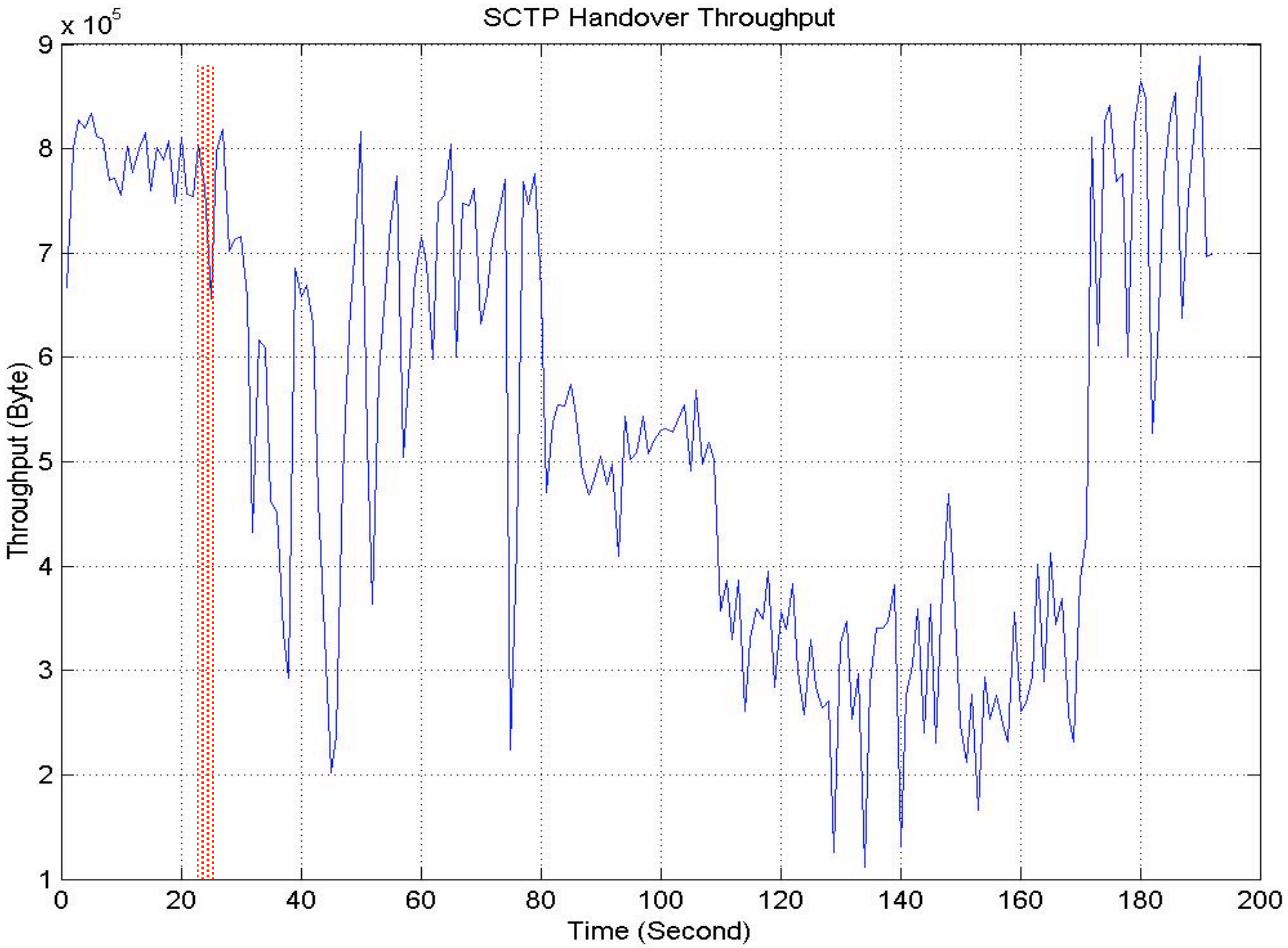
Mobile IP Testbed



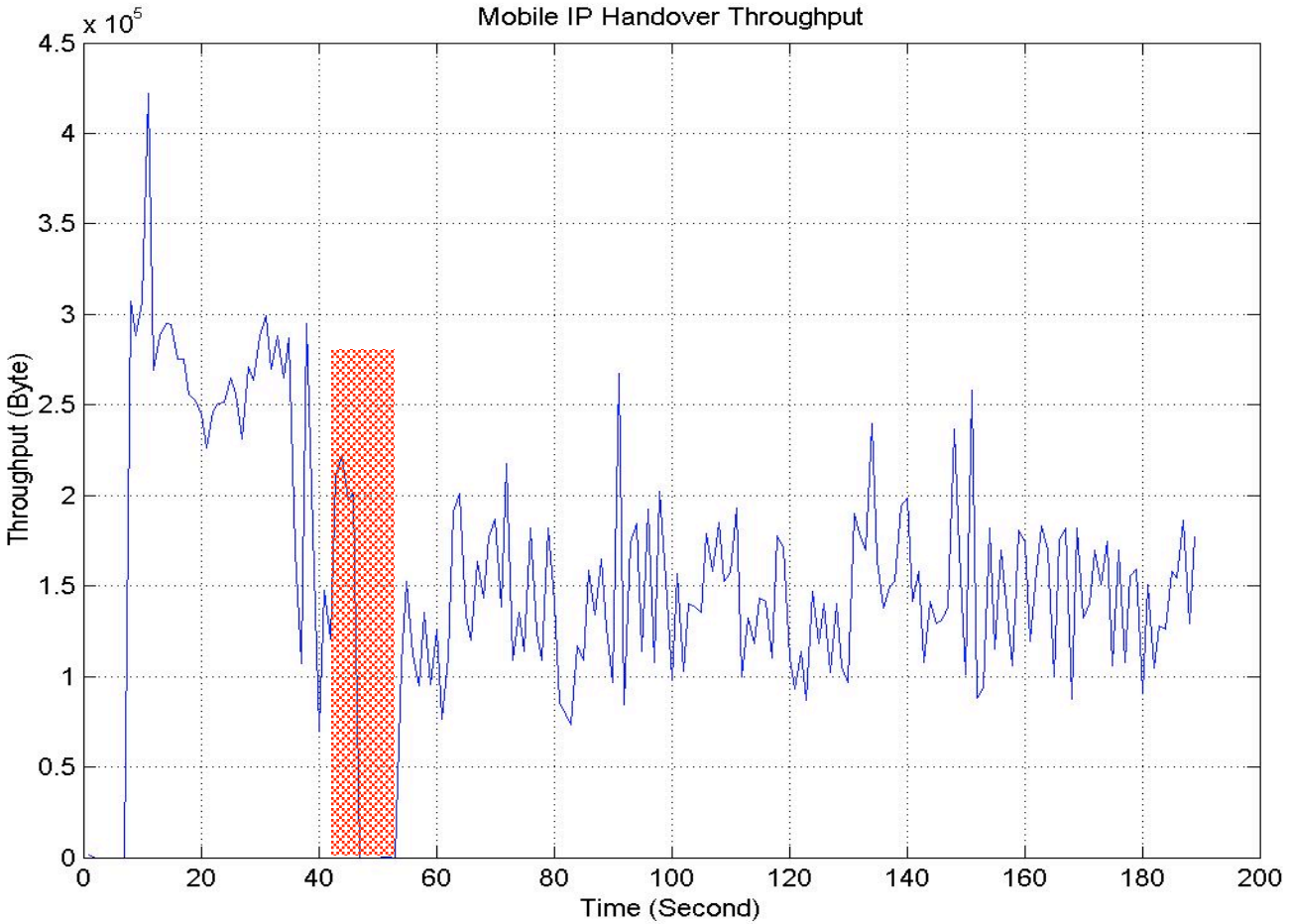
TraSH Testbed Components

- SCTP – We used the LK-SCTP Linux Kernel implementation.
- Linux OS – Version 2.6.2.
- Network adapters – our implementation used an Avaya PCMCIA wireless network card and a NETGEAR USB wireless network card.

TraSH: Preliminary Results



Mobile IP Results



Work to date

- Developed ns-2 module for multihomed mobile wireless node
- Completed the handover timeline for TraSH-SN
- Preliminary simulation study between TraSH and Mobile IP
- Implemented a testbed for testing Mobile IP vs TraSH
  - Linux based system using open source lk-sctp implementation
- Completed design document for implementing TraSH-SN

Future Work

- Analytical Modeling of TraSH performance in terms of throughput, packet loss, handover latency, scalability, and survivability.
- Interoperation of TraSH with firewalls and AAA servers.
- Efficient secret key management/distribution in TraSH.
- Apply TraSH into vertical handover.
- QoS related issues.
- Optimal handover time
- Video streaming over TraSH-SN
- Investigate possibility of ***technology transfer/infusion*** into real NASA projects

Papers/Talks/Standardization

Completed

- S. Fu and M. Atiquzzaman, "**SCTP: State of the art in Research, Products, and Technical Challenges**", IEEE Communications Magazine, vol. 42, no. 4, April 2004, pp. 64-76.
- S. Fu and M. Atiquzzaman, "**SCTP: State of the art in Research, Products, and Technical Challenges**", IEEE Computer Communications Workshop (CCW 2003), Dana Point, California, October 20-21, 2003, pp. 85-91. (***Invited Paper***).
- "**Interoperability and Security of TraSH: A Transport Layer Seamless Handover**", Mohammed Atiquzzaman as panelist at the 23rd IEEE International Performance, Computing, and Communications Conference, April 16, 2004, Phoenix, AZ.
- Various internal technical reports

In Progress

- M. Atiquzzaman, "TraSH: A Transport Layer Handoff Protocol for Mobile Terrestrial and Space Networks", ***Keynote speech*** to be given at 1st International Conference on E-business and Telecommunication Networks
- S. Fu, M. Atiquzzaman, L. Ma, W. Ivancic,Y-J. Lee, J. S. Jones, S. Lu, "**TraSH: A Transport Layer Seamless Handover for Mobile Networks**", submitted to Globecom 2004.
- S. Fu, M. Atiquzzaman, L. Ma, "**Performance Comparison of TraSH and Mobile IP**", submitted to Globecom 2004.
- W. Eddy, J. Ishac, M. Atiquzzaman, "**An Architecture for Transport Layer Mobility**", to be submitted as Internet Draft.